MARCONI AND THE BEGINNINGS OF WIRELESS COMMUNICATION

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COURTESY OF THE BETTMANN ARCHIVE

Guglielmo Marconi at the receiving set at St. John's, Newfoundland.

NOW that men have walked on the moon it is difficult to envision an era in which the thought of communicating over great distances through space would be dismissed as an idle dreamer's fancy. Yet such was the skepticism which greeted Guglielmo Marconi's announcement of his system for wireless telegraphy in 1896. Lord Kelvin is reported to have said at this time, "Wireless is all very well but I'd rather send a message by a boy on a pony."

Guglielmo Marconi, who was born one hundred years ago in Bologna on April 25, 1874, was one boy whose interests were not in ponies. He was the son of an Italian country landowner and an Irish mother, Annie Jameson. As a child, young Guglielmo led a sheltered life, awed by his father, protected by his mother, and schooled at home by private tutors.

The household library provided a source of relief from the routines imposed upon him. Greek mythology and history were his early interests. Soon, though, Benjamin Franklin replaced Achilles, and Faraday's lectures on electricity became more fascinating to him than the Peloponnesian Wars.

When Marconi was 10 years old he was telling his cousin, Daisy Prescott, about "my electricity . . ." At 13, he set up a device to distill alcohol (perhaps following the example of his grandfather Andrew Jameson, noted purveyor of Irish whiskey). Such scientific endeavors infuriated his father, Giuseppe. The elder Marconi, 17 years older than his wife, viewed his son's experiments as being extravagant and wasteful.

An experiment in which Guglielmo sent high voltage electricity through dinner plates caused them to scatter and break. Enraged by this event, Giuseppe thereafter systematically destroyed his son's apparatuses. Guglielmo and his mother were then forced to hide them from him.

Nevertheless, the boy persevered. Enrolled in the Technical Institute in Livorno, Marconi was stimulated by the lectures in electricity. His mother arranged for private lessons for him in electric theory with Vincenzo Rosa. She provided the encouragement and support necessary for the young boy, and at the age of 16 Marconi built his own machine for transmitting electricity.

ELECTRICITY had been studied in Europe since the work of Gilbert in England during the reign of Elizabeth I. At the University of Bologna in 1791, Luigi Galvani observed that a dead frog's leg moved when touched simultaneously with a zinc and a copper wire. Nine years later, his countryman, Alessandro Volta, inferred that a continuous electric current is generated by two dissimilar metals separated by a salt solution.

In the United States, Joseph Henry discovered, in 1842, that an electric spark can induce a current in wires far removed from the source of the spark. About the same time, Samuel Morse perfected a telegraph based upon principles of electromagnetic induction, developed by Ampère and Oersted. In England, Michael Faraday, working independently of Henry, also discovered induced electricity.

The Scottish physicist James Clerk Maxwell attempted to translate Faraday's discovery into mathematical formulae. In 1864 and later in 1873, Maxwell published his theory of the electromagnetic field. He concluded that electricity and magnetic energy travel in transverse waves that move through a vacuum at the same speed as light waves. He also demonstrated how all electric phenomena can be reduced to stresses and motions of a material medium.

According to Maxwell's equations, an oscillating charge initiates electro-

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magnetic waves. Heinrich Hertz, the German physicist, studied Maxwell's theories and attempted to verify them experimentally. In 1887, eight years after Maxwell's death, Hertz devised an apparatus which would produce a spark several inches long when he pressed a key connected to a high-voltage source. This device acted as a transmitter. Several yards away a similar apparatus with a smaller spark gap served as a receiver. After opening and closing the transmitter key, Hertz found that a very small portion of the large amount of energy supplied to the transmitter had reached the receiver. He concluded that the energy had been radiated from the transmitter to the receiver in the form of electromagnetic waves. On the basis of his experiments, Hertz was able to confirm Maxwell's prediction of the speed of these waves, as well as his theory.

Seven years after Heinrich Hertz' premature death at the age of 36, in 1894, Guglielmo Marconi, now 20, read a magazine article describing Hertz' work. It was written by Professor Righi of the University of Bologna. Marconi, for all of his early creativity in science, had been refused admission to the University of Bologna the previous fall, because he could not pass the matriculation examination. (Nor was he able to enter the Naval Academy at Livorno.) Marconi received permission to audit Professor Righi's courses in electricity, however. The professor lived close to the Marconi Villa Grifone estate, and he was persuaded by Signora Marconi to allow her son to set up experiments in his laboratory.

After reading Righi's article, Marconi was struck with the idea of using Hertzian waves in wireless telegraphy. He spoke to Professor Righi about his plans. The professor suggested that Marconi would be unable to make any breakthroughs as he lacked the necessary theoretical background. Guglielmo was determined, nevertheless, to perfect a means of applying Hertz' discoveries.

The first step for Marconi was to repeat Hertz' experiments. His mother set aside two large rooms of the house for his investigations. His father Giuseppe, still disapproving, offered no funds for or understanding of his son's work.

Marconi's apparatus had several improvements over Hertz' original device. A curved reflector served to direct the waves towards the receiver. A more sensitive receiving system designed by the French physicist Edouard Branly, and also worked upon by Oliver Lodge of England, replaced the spark gap in the receiver. The Branly coherer consisted of a small glass tube filled with fine metal dust. At each end was an electrical contact. As the electromagnetic radiation on the coherer increased, the electrical resistance between the contacts decreased.

By connecting the coherer in a circuit with a battery and a buzzer, it became possible to detect the reception of electromagnetic waves. When these waves were received, the resistance of the coherer would decrease, creating an increase in the current of the circuit large enough to cause the buzzer to sound. The coherer made it possible to demonstrate the reception of very small amounts of energy.

By the end of 1894, Marconi was able to depress his key at one end of the attic and to hear the buzzer sound 30 feet away. He demonstrated this to his father, transmitting the letter *S* in Morse code. Although Giuseppe was not convinced of the ultimate practicality of his son's work, he relented and advanced enough money for further research.

The problem to be solved was how to increase the distance between the transmitter and the receiver. Marconi began a systematic refinement of his equipment. It was an extremely tedious and difficult task to rearrange circuits and to use different combinations of materials. His patience and determination resulted in a major modification of the coherer. Marconi discovered that a fine metallic dust mixture of 95 percent nickel and 5 percent silver in a narrower glass tube which had been evacuated of air would provide a more sensitive instrument.

Another improvement, allowing for a greater distance of transmission, was the connection of metal plates to the spark gap in the transmitter and also to the terminals of the coherer in the receiving apparatus. During the spring and summer of 1895, Marconi strung his equipment in the fields of his father's estate. The distances increased, but he had not yet solved the problem.

COURTESY OF RCA NEWS

David Sarnoff and Guglielmo Marconi in 1933, at the RCA transmitting center at Riverhead, Long Island.

The fundamental difficulty was that an oscillator spreads its energy very broadly in all directions. (The term broadcast originates from the nature of this energy dispersal.) Only a minute amount of the total energy will be received at any appreciable distance. Therefore, it was necessary to design a device which could transmit greater quantities of energy.

Marconi attempted to increase the wavelength of the transmitted waves. He began by fitting even larger metal plates to the apparatus. Degna Marconi quotes her father as saying, "I found out then how to obtain waves at distances of hundreds of meters. By chance I held one of the metal slabs at a considerable height above the ground and set the other on the earth. With this arrangement the signals became so strong that they permitted me to increase the sending distance to a kilometer."

Marconi had actually invented the vertical aerial—now seen in the tall towers symbolizing the broadcast industry. He then replaced the plates with copper wires, and by September 1895, at the age of 21, Marconi was ready to offer his discovery to his country.

The Italian Ministry of Posts and Telegraphs rejected the offer. Disappointed at his country's attitude, Guglielmo was encouraged by his mother to seek support in her native land, Great Britain.

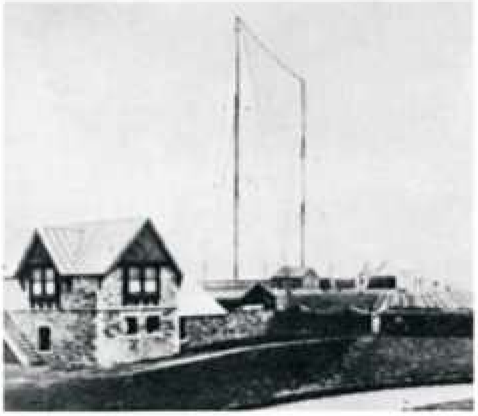
He arrived with her in London in February 1896, and according to the New York *Times* of December 15, 1901, "when first reaching England, Signor Marconi received a setback. His instruments were mistaken by the Custom House authorities for bombs and infernal machines, and were accordingly broken up."

However, with the help of a cousin, Henry Jameson-Davis, he set up a laboratory and repaired his equipment. On June 2, 1896, he filed provisional specifications with the patent office, and on July 2, 1897, the patent for Marconi's wireless was granted.

During this time he worked with William Preece, chief engineer of the British Post Office, who also experimented with the wireless. Preece saw the value of Marconi's invention in ship-to-shore communication. Older than Marconi (Preece was 63, Marconi was 22), he helped the young Italian publicize his method. Tests on Salisbury Plain and across the British channel greatly increased the transmission distance. Balloons and kites were used to increase the height of the aerial.

Jameson-Davis obtained financial backing and incorporated the Wireless Telegraph and Signal Company to realize the commercial possibilities of Marconi's patent. This company was renamed the Marconi Wireless Telegraph Company. Its United States branch later became the Radio Corporation of America (RCA).

THE next few years were marked by successive triumphs: communication from ship to shore in Italy, from Britain to France across the English Channel, between British battleships 75 miles apart, and reporting of the results of the America's Cup Yacht Races in New York. However, Marconi's greatest success was yet to come.



COURTESY OF THE BETTMANN ARCHIVE

Marconi's transmission station in Poldhu, on the coast of Cornwall, England.

Would it be possible to transmit radio waves across the Atlantic, to link Britain with the United States? Both the transmitter and the receiver had to be more powerful than any previously designed. In Poldhu, on the Cornish coast of England, Marconi set up a high antenna consisting of 20 poles each 200 feet high in a circle 200 feet in diameter. In 1901, after construction in England was complete, Marconi decided to build the receiver in South Wellfleet on Cape Cod. The design would be identical with that in Cornwall.

After successfully using the Poldhu installation to transmit over 230 miles, the transatlantic venture received a devastating setback. Severe storms wrecked the tall masts which had been erected on Cape Cod. An attempt to replace them was doomed by even more violent storms three months later, in November 1901.

Refusing to accept defeat, Marconi decided to use crude equipment consisting of balloons and kites to raise the aerial. He selected St. John's, Newfoundland, as his new site. The letter *S* was to be transmitted in Morse code at prearranged times on December 12. With his kite flying high, this modern Benjamin Franklin received the three dots from across the sea.

Some remained skeptical. If radio waves are like light waves, they will travel in straight lines, and therefore it would be impossible for them to bend around the earth's curvature the distance from Newfoundland to England, they said. The London *Daily Telegraph* on December 18, 1901 wrote, "there was an indisposition . . . to accept as conclusive his evidence that the problems of wireless telegraphy across the Atlantic had been solved."

(Within a year, Arthur Kennelly of the United States and Oliver Heaviside of England proposed the theory that a reflecting layer existed at high altitudes which would cause radio waves to bounce back to the earth. This theory was verified in 1924.)

Marconi returned to Cape Cod and constructed new receiving and transmitting devices. On January 19, 1903, King Edward VII of Great Britain and President Theodore Roosevelt exchanged Morse code greetings via wireless telegraphy. Four years later commercial service was inaugurated.

Marconi received many honors, both political and scientific, and was awarded the Nobel Prize in 1909. In his later life he served as an Italian envoy to negotiations for the Treaty of Versailles and as a part-time diplomat. His personal life was marred by domestic problems, and his company was involved in a political scandal in Britain, but he continued his study of radio waves, predicting radar as early as 1922.

The career of Guglielmo Marconi illustrates how the nurturing of the creative sparks of childhood coupled with the qualities of perseverance and dedication can set the stage for scientific discovery. Marconi's systematic procedures, his improvement upon the work of others, and his insight combined to bring him his ultimate success. □

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